DUAL-STRING DYNAMOMETER FOR MEASURING DENTAL HANDPIECE POWER AT HIGH SPEED AND LOW TORQUE

TECHNICAL FIELD

[0001] The present invention is generally related to string tension dynamometers used to measure power in a high speed, low torque dental handpiece. More particularly, the invention relates to such a dynamometer employing dual or two strings in order to avoid a lateral force being exerted on the test wheel. The lateral forces are balanced resulting in a total lateral force net value of zero.

BACKGROUND OF THE INVENTION

[0002] The power output of high-speed, low torque dental handpieces, such as air turbine handpieces, can be measured using a string tension dynamometer. For example, it is know to use a Kerfoot string tension dynamometer, which is a device that applies a load to a handpiece through a string looped around a pulley mounted in a handpiece chuck (See FIG. 1). String tension is measured by the deflection of weighted dials to which the ends of the string are attached. Under steady-state conditions, the net tension on the string multiplied by the pulley radius is equal to the handpiece torque.

[0003] According to one test protocol, the face of the pulley is half blacked out for speed detection using an optical tachometer. The pulley shaft conforms to DIN 13950 and ISO 1797 (0.0628", 1.595 millimeters diameter). The pulley wheel is lightweight aluminum, unconcentricity not more the 0.0003 inches. Each pulley is tested for balance

at speeds up to 500,000 RPM by recording the free spin RPM of a new handpiece with each pulley and discarded if they are statistical outliers. The maximum power output of a handpiece occurs at a speed that is about half the no-load (or free-running) speed. To determine the power output, the maximum speed and the torque at half the maximum speed is measured. Torque and power can be measured as follows:

$$P=vT, \text{ where } v = RPM\,(2\pi)/60 \text{ and } T=(T_R - T_L)mgR$$

P is the power in Watts.

v is the speed expressed as angular velocity, radians per second.

RPM is the speed in revolutions per minute at which the torque was measured.

π is the constant 3.14159.

T is the torque expressed as Newton-meters.

TR and **TL** are the right and left dial deflection readings (See FIG. 1).

m is the mass of the dial weights expressed in kilograms.

g is the gravitational acceleration, about 9.8 meters per second^2.

R is the pulley radius in meters (such as for example, 0.100" or 2.54×10^{-3} meters). The actual pulley radius is adjusted to compensate for the thickness of the string. The effective pulley radius including the radius of the string is 0.100".

[0004] While such dynamometers have proven valuable in determining power, they do result in a small lateral force being exerted on the test wheel. Therefore, a purely

torsional load never exists resulting in increased measurement error. A need exists therefore, for a string tension dynamometer which will avoid the torsional load-induced errors.

SUMMARY OF THE INVENTION

[0005] A dual-string tension dynamometer according to the present invention utilizes two strings. The lateral forces are balanced such that the total lateral force net value is zero. The results reflect purely torsional loading.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a schematic representation of a Prior Art single string tension dynamometer, showing the left and right dial deflection readings as T_L and T_R respectively. The force vector representing tension at T_S is equal to the sum of T_L and T_R.

[0007] FIG. 2 is a schematic representation of a dual-string tension dynamometer according to the present invention.

PREFERRED EMBODIMENT FOR CARRYING OUT THE INVENTION

[0008] A single-string dynamometer works on the premise that the tension difference between two sides of a load string equals the force applied to a test wheel at that specific radius. By summing vectors a resultant vector is found. This resultant cannot be zero due to the nature of the dynamometers operation. Additionally, this vector may include an orthogonal component if the load string is not mounted tangent to the test wheel.

According to the present invention, adding a second string introduces a second set of forces. By keeping appropriate tension magnitudes equal, a zero net force results. A state of purely torsional loading has been reached.

[0009] A dual-string dynamometer 1 according to the invention includes two filaments 10 and 11, wrapped around approximately ninety degrees of a test wheel 12. A conventional control device (not shown) may be introduced to maintain equal tensions and a zero lateral load. Power values are determined by multiplying torque values with angular speed data. Such relationships are expressed according to the following equations, where A, B, C, D, E and F are force vectors at indicated points of the filaments 10 and 11 as shown on FIG. 2.

$$E = A + C$$

$$F = B + D$$

$$E + F = 0$$

[0010] A is the tension on one end of string 10; B is the tension on a same side of string 11; C is the tension on the other side of string 10 from A; D is the tension on the other side of string 11 from B; as is shown representationally in FIG. 2.

[0011] A dual-string dynamometer 1 as described eliminates lateral loading, which provides loading condition certainty. High speed, low torque power data can be accurately attained in an otherwise conventional manner.

[0012] It will be appreciated that according to the present invention, any arrangement using two strings could be used. String wrap angle, wheel size, and string material can be

altered in order to accommodate testing situations. Any means of controlling string tension could be used with varying degrees of accuracy. Further, while such a device is especially useful in testing dental high speed, low torque handpieces, such a device has application to any number of applications. It has been described herein with respect to the testing of dental handpieces only for exemplary purposes and should not necessarily be so limited. The invention is limited only by the scope of the attached claims.